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OPERATION OF THE TONTO FOREST SEISMOLOGICAL OBSERVATORY

Teledyne Geotech

Prepared for:

Advanced Research Projects Agency

30 April 1973

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TECHNICAL REPORT NO. 73-5

OPERATION OF THE TONTO FOREST SEISMOLOGICAL OBSERVATORY

Quarterly Report No. 3, Project VT/3704
Contract F33657-72-C-0800
1 January through 31 March 1973

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13. ABSTRACT

This is a report of the work accomplished on Project VT/3704 from 1 January through 31 March 1972. It describes the operation, evaluation, and improvement of the Tonto Forest Seismological Observatory (TFSO) located near Payson, Arizona, research and test functions carried out at the TFSO, and research and development tasks performed by the Garland, Texas, staff using TFSO data.

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1. INTRODUCTION

1.1 AUTHORITY

The work described in this report was supported by the Advanced Research Projects Agency, Nuclear Monitoring Research Office, and was monitored by the Air Force Technical Applications Center (AFTAC) under Contract F33657-72-C-0800. The effective date of the contract is 1 July 1972; the Statement of Work for Project VT/3704 is included in this report as appendix 1.

1.2 HISTORY

The Tonto Forest Seismological Observatory (TFSO) was constructed by the United States Corps of Engineers in 1963. TFSO was designed to record seismic events and to be used as a laboratory for testing, comparing, and evaluating advanced seismograph equipment and seismometric recording techniques. The instrumentation was assembled, installed, and operated until 30 April 1965, by the Earth Sciences Division of Teledyne Industries under Contract AF 33(657)-7747. On 1 May 1965, Geotech assumed the responsibility of operating TFSO. The location of TFSO is shown in figure 1. Vault locations for sensors in the standard observatory seismographs are shown in figure 2.

2. OPERATION OF TFSO

2.1 GENERAL

Data are recorded continuously at the TFSO for 24 hours each day of the week. The instrumentation that accomplishes this, and other instrumentation that is used for special tests, have been operated and maintained during this report period by a staff of five technical people. Administrative work is handled by one half-time person. All work is being accomplished during a "normal shift" from 8:00 a.m. to 5:00 p.m., and a "late shift" from 9:30 a.m. to 6:00 p.m. The normal work shift is worked each Monday through Friday except holidays and is considered the regular work day by all personnel. The late shift is worked every day including Saturdays, Sundays, and holidays, and is staffed by one man on a rotational basis.

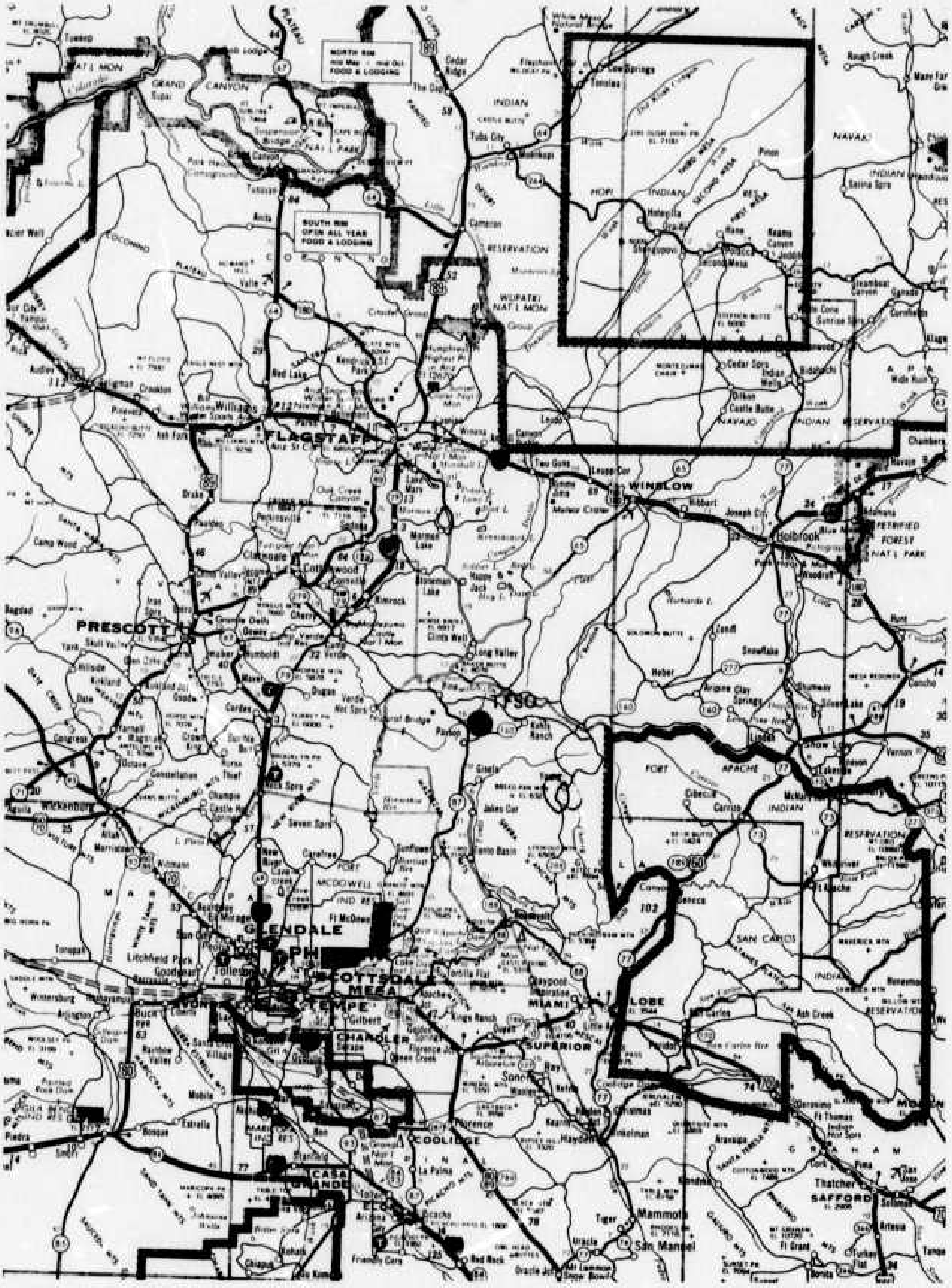

Figure 1. Location of the Tonto Forest Seismological Observatory

G 4970

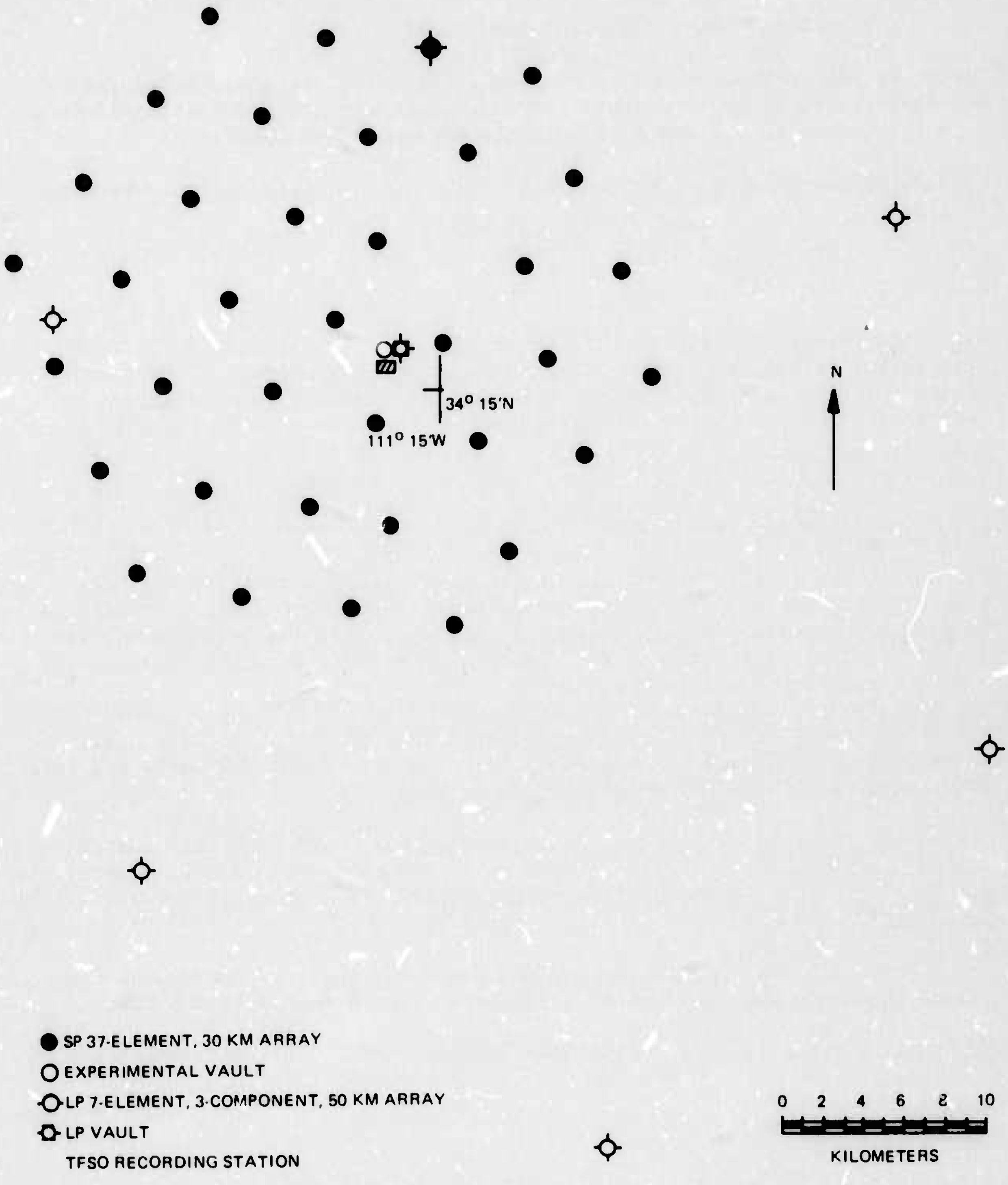

Figure 2. Vault locations in the 37-element short-period array, and the 7-element long-period array at TFSO

G 6922

2.2 STANDARD SEISMOGRAPH OPERATING PARAMETERS

The operating parameters and tolerances for the TFSO standard seismographs are shown in table 1. Frequency response tests are made routinely and parameters are checked and reset to maintain the specified tolerances.

Normalized response characteristics of TFSO standard seismographs are shown in figure 3.

2.3 DATA CHANNEL ASSIGNMENT

Each data format recorded at TFSO is assigned a Data Group number. When a data format is changed, a new Data Group number is assigned. Data Format Change Notices reporting changes in channel assignments were submitted to the Project Officer and to frequent users of the TFSO data during this report period.

2.4 COMPLETION AND SHIPMENT OF DATA

Four analog FM magnetic-tape units were used to record data for the VELA Seismological Center (NYV). Tapes from these units were shipped weekly. All tapes recorded on 1 day were shipped to our Garland, Texas, laboratory for quality control, then shipped to the SDL. All tapes recorded on the other 6 days were shipped directly to the SDL.

All ASDAS tapes, except two per week that were sent to Garland for quality control, were held at the observatory for a period of about 8 weeks and then were recycled, if not requested by a data user.

All Develocorder (16-millimeter film) seismograms, except quality control copies, were routinely shipped to the SDL. One seismogram for each Develocorder was sent each week to our Garland, Texas, laboratory for quality control, then forwarded to the SDL.

One DGRDAS tape was sent to Garland each week for quality control, then was forwarded to the SDL. All other tapes were shipped weekly to the SDL.

Copies of calibration and operational logs accompanied all data shipments.

2.5 QUALITY CONTROL

2.5.1 Quality Control of 16-Millimeter Film Seismograms

Quality control checks of randomly-selected 16-millimeter film seismograms from Data Trunks 2, 4, and 8 and the associated logs were made in Garland. Items that were routinely checked by the quality control analyst include:

a. Film boxes - neatness and completeness of box markings;

Table 1. Operating parameters and tolerances of standard seismographs at TFSO

Seismograph				Operating parameters and tolerances				Filter settings		
System	Comp	Type	Model	Ts	λs	Tg	λg	Model	Bandpass at 3 dB cutoff (sec)	Cutoff rate at SP side (dB/oct)
SP[a]	Z	Johnson-Matheson	6480	1.25 ±2%	0.54 ±5%	---	---	2888-1	0.2 - 1.0	6
SP[b]	Z	Johnson-Matheson	6480	1.25 ±2%	0.54 ±5%	0.33 ±5%	0.65 ±5%	6824-1	0.1 - 100	12
SP[b]	H	Johnson-Matheson	7515	1.25 ±2%	0.54 ±5%	0.33 ±5%	0.65 ±5%	6824-1	0.1 - 100	12
SP	Z	Benioff	1051	1.0 ±2%	1.0 ±5%	0.2 ±5%	1.0 ±5%	6824-1	0.1 - 100	12
SP	H	Benioff	1101	1.0 ±2%	1.0 ±5%	0.2 ±5%	1.0 ±5%	6824-1	0.1 - 100	12
SP	Z	UA Benioff	1051	1.0 ±2%	1.0 ±5%	0.75 ±5%	1.0 ±5%	---	---	--
BB	Z	Press-Ewing	SV-282	12.5 ±5%	0.45 ±5%	0.64 ±5%	9.0 ±5%	6824-7	0.05- 100	12
LP	Z	Geotech	7505A	20.0 ±5%	0.77	---	---	30024	80 - 300	[illegible]
LP	H	Geotech	8700C	20.0 ±5%	0.77	---	---	30024	80 - 300	6

KEY

SP Short period
IB Intermediate band
LP Long period
UA Unamplified (i.e., earth powered)
BB Broad band

Ts Seismometer free period (sec)
Tg Galvanometer free period (sec)
λs Seismometer damping constant
λg Galvanometer damping constant

[a] 37-element hexagonal array

[b] Linear array and 3 comp

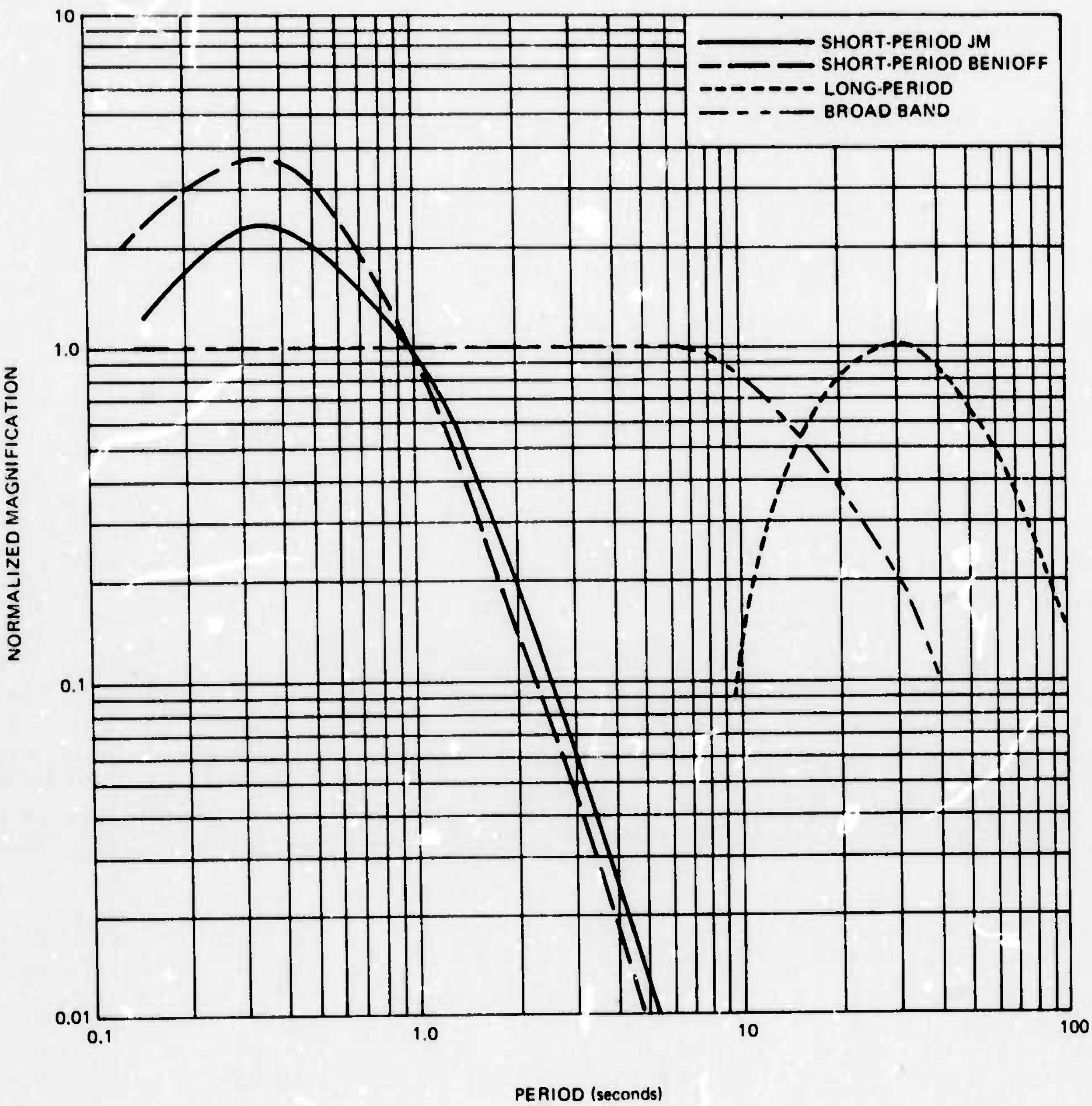

Figure 3. Normalized response characteristics of standard seismographs at TFSO

G 5048

b. Develocorder logs - completeness, accuracy, and legibility of logs;

c. Film -

(1) Quality of the overall appearance of the record (for example, trace spacing and trace intensity);

(2) Quality of film processing.

d. Results of these evaluations were sent to the observatory for their review and comment.

2.5.2 Quality Control of Analog FM Magnetic-Tape Seismograms

Each week, quality control checks of three randomly-selected magnetic-tape seismograms are made in Garland and at TFSO to assure the recordings meet specified standards. The following items are checked:

a. Tape and box labeling;

b. Accuracy, completeness, and neatness of logs;

c. Adequate documentation of logs by voice comments on tape where applicable;

d. Seismograph polarity;

e. Level of the microseismic background noise;

f. Level of calibration signals;

g. Relative phase shift between array seismographs;

h. Level of system noise;

i. Oscillator alignment;

j. Quality of recorded WWV signal where applicable;

k. Time-pulse carrier;

l. Binary-coded digital time marks.

2.5.3 Quality Control of ASDAS Magnetic-Tape Seismograms

Quality control checks of ASDAS tapes are made routinely. At present, one tape from each of the two transports is checked weekly for the following items;

a. Neatness and accuracy of the associated logs;

b. Polarity errors;

c. Recording level of each channel;

d. Fidelity of reproduction;

e. Presence of header record and correct record length;

f. Tape parity errors;

g. Timing information.

2.5.4 Quality Control of DGRDAS Magnetic-Tape Seismograms

Quality control checks of DGRDAS tapes are made routinely. At present, one tape is checked each week for all items listed under section 2.5.3, and, in addition, for the following items;

a. Field transmission parity errors;

b. Central digital system parity errors;

c. Gain code errors.

2.6 EMERGENCY POWER GENERATOR

The 100 kW diesel-powered generator was operated for a total of 19.6 hours. It was tested for 8.4 hours, and furnished full observatory power for 11.2 hours during commercial power failures. Maintenance to the emergency power system included the replacement of storage batteries and switch contacts.

2.7 FACILITY MAINTENANCE

The TFSO facilities were maintained in accordance with sound industrial practices throughout the report period. This work included pest extermination, work area cleaning, and lubrication and cleaning of heating and air conditioning equipment.

The old furnace control unit at the CRB was replaced with a new unit on 4 January. The heating system has operated without failure since that time.

Minor repairs were made to the air-conditioning system. These included the replacement of a bearing and a seal, the charging of air chillers with refrigerant, and the replacement of a ruptured radiator coil.

Building maintenance included the painting of the outside doors and several rooms in the CRB, and temporary repairs to metal roofs on the shop and the storage buildings.

2.8 WEATHER

Weather was a major factor in limiting the outdoor work that could be accomplished to maintain the field instrumentation and cables in an operating condition. Rain or snow fell during 43 of the 90 days in this report period and kept the roads and trails impassable much of the time. A total of 10.03 inches of rain and 51 inches of snow fell. Lightning was observed on 9 days, and the temperature ranged from a maximum of 56 degrees F to a minimum of 5 degrees F.

2.9 RELOCATION OF LP6

All construction work at the LP6 remote site is complete, and the commercial power is available. Data transmission from the site to the CRB will be started when telephone service is made available by the telephone company.

2.10 SPIRAL-4 CABLES

Forty-nine sections of spiral-4 cable were repaired during the report period. Many other sections were defective, but were not repaired because precipitation made access roads and trails to those cables impassable. Forty-three cables failed because of insulation deterioration, five were cut by road maintenance equipment, and one was damaged by vandals. Forty-four new sections of cable were installed; two sections, previously used in the outer ring, were reconnected to inner ring circuits; and three splices were made.

2.11 IMPROVE TFSO INSTRUMENTATION

The following work was directed toward the improvement of TFSO instrumentation in accordance with the requirements of Supplemental Agreement P00005 to Contract F33657-72-C-0800.

2.11.1 Install Telemetry Circuits

Detailed planning of the circuits and installation was completed. Procurement of radio equipment and antennas is awaiting receipt of frequency assignments from the Air Force.

2.11.2 Improve Field Equipment

Rain, snow, and impassable roads prevented the accomplishment of any work on this task. Work will be started after stream and river levels fall back to normal, and roads and trails dry out.

2.11.3 Improve CRB Cables

Approximately 15 miles of damaged and excess cable were removed from the crawlways and cableways in the CRB. The remaining cables were traced and identified. Eighty percent of the required work has been completed. The remaining 20 percent involves the replacement of corroded ground wiring.

2.11.4 Refurbish Magnetic-Tape Recorders

A maintenance technician from Honeywell, Inc., worked at the TFSO intermittently during the report period to maintain and repair the FM magnetic-tape recorders. This task is approximately 60 percent complete.

2.11.5 Facility Maintenance

The following tabulation lists facility maintenance tasks and indicates their completion status.

% complete	Task
0	Insulate pipes
0	Rehabilitate array cable trails and access roads
100	Paint rooms in CRB and interior of shop
0	Patch and seal asphalt road and parking lot
90	Repair air handling units in mechanical room
50	Repair chillers
0	Recharge air conditioner in engineering laboratory
0	Pull jet and service water well
100	Replace motors and clean evaporation tank in sewage system
100	Service Caterpillar generator and replace battery
90	Reline furnace and replace burner unit
50	Replace motors in the cooling water tower
0	Relocate smoke stack system in furnace room
50	Fabricate and replace SP vault covers

2.11.6 Lightning Protection

All modifications to the CRB power circuits for channels Z1 through Z10 were completed. Seven of the ten field sites have been modified.

2.11.7 Precure Digital Recorder

The new Peripheral Equipment Corporation digital magnetic-tape recorder was procured and installed on 27 March. It has been recording LP array data routinely since that date.

2.12 INVESTIGATE SIGNAL ACQUISITION AND TRANSMISSION

On 21 February 1973, a Task Change Proposal, P-2164, was submitted. This recommended that a program be undertaken to investigate the signal range and technique needed to acquire and transmit low frequency data from remote instrument locations.

3. INSTRUMENT EVALUATION

3.1 DIGITAL GAIN RANGING DATA ACQUISITION SYSTEM

The digital gain-ranging data acquisition system (DGRDAS) was operated throughout the report period with interruptions for record changes, scheduled maintenance, and for the installation, on 27 March, of the new PEC magnetic-tape recorder. The tape parity errors dropped from a marginally acceptable number to an insignificant number when the new transport was installed.

3.2 ASTRODATA SEISMIC DATA ACQUISITION SYSTEM

The Astrodata seismic data acquisition system was operated routinely except for scheduled maintenance, record change, and the replacement of vacuum motor brushes, capstan drive belts, a vacuum motor, and a switch.

3.3 MULTICHANNEL FILTER

The multichannel filter was not operated during this report period.

3.4 GRAVITY FEED CHEMICAL SUPPLY SYSTEM

The gravity-feed chemical supply system for the TFSO Develocorders continued to provide an unsatisfactory performance, failing four times during January. To obtain a better performance, the system was modified as described in the Test Plan presented in appendix 2 of this report. The newer system features

common chemical supply reservoirs for all Develocorders, and a larger chemical supply pressure. Figures 4 and 5 show photographs of the modified system.

An early review of the newer system performance indicates that Develocorder film record quality has significantly improved, but that for best performance, flow rates must be monitored and adjusted. The flow of fixer to one Develocorder has failed once during February and once during March. The simplified chemical handling procedures, which involve replenishment of one type of chemical to each of 3 large centralized containers, has reduced the spilling of chemicals onto the Develocorders and the surrounding furniture.

Chemical flow rates were adjusted to the minimum that would produce good quality recordings. The total volume of chemicals used from 5 February to 29 March, and their usage rates are as follows:

Dilute chemical	Volume used in 52 days gallons	Approx. no. gal. per day	Number of Develocorders
Fixer	24.7	0.5	7
LP developer	10.0	0.2	4
SP developer	3.0	0.06	3

At present, each central chemical container is filled when its fluid level has dropped approximately one gallon.

3.5 SHORT-PERIOD 37-ELEMENT SEISMOGRAPH ARRAY

Figure 6 is a bar graph that presents, chronologically by channel, the operational status of the SP array. Four channels were inoperative during the entire report period, 9 other channels were inoperative during some portion of the report period, and 11 channels were noisy during some portion of the report period. The channel malfunctions were caused by failures of 49 sections of spiral-4 cable, 2 amplifiers, and 2 isolation filters.

3.6 LONG-PERIOD SEISMOGRAPH ARRAY

The bar graph in figure 6 presents the chronological status of the LP array during the report period. The LP6 channels were inoperative because telephone circuits between the CRB and the LP6 sites have not yet been installed by the telephone company. Fifteen of the other channels were inoperative or noisy during part of the period. Some of the lost operating time was caused by two commercial power failures; one telephone circuit failure and one telemetry transmitter failure. The majority of the lost time was caused by rain and snow, which saturated the earth with moisture, causing the vaults to tilt and disable seismometers, and which penetrated spiral-4 cables, causing electrical noise and failures. The poor weather has prevented a detailed determination of the spiral-4 cable condition in the LP array.

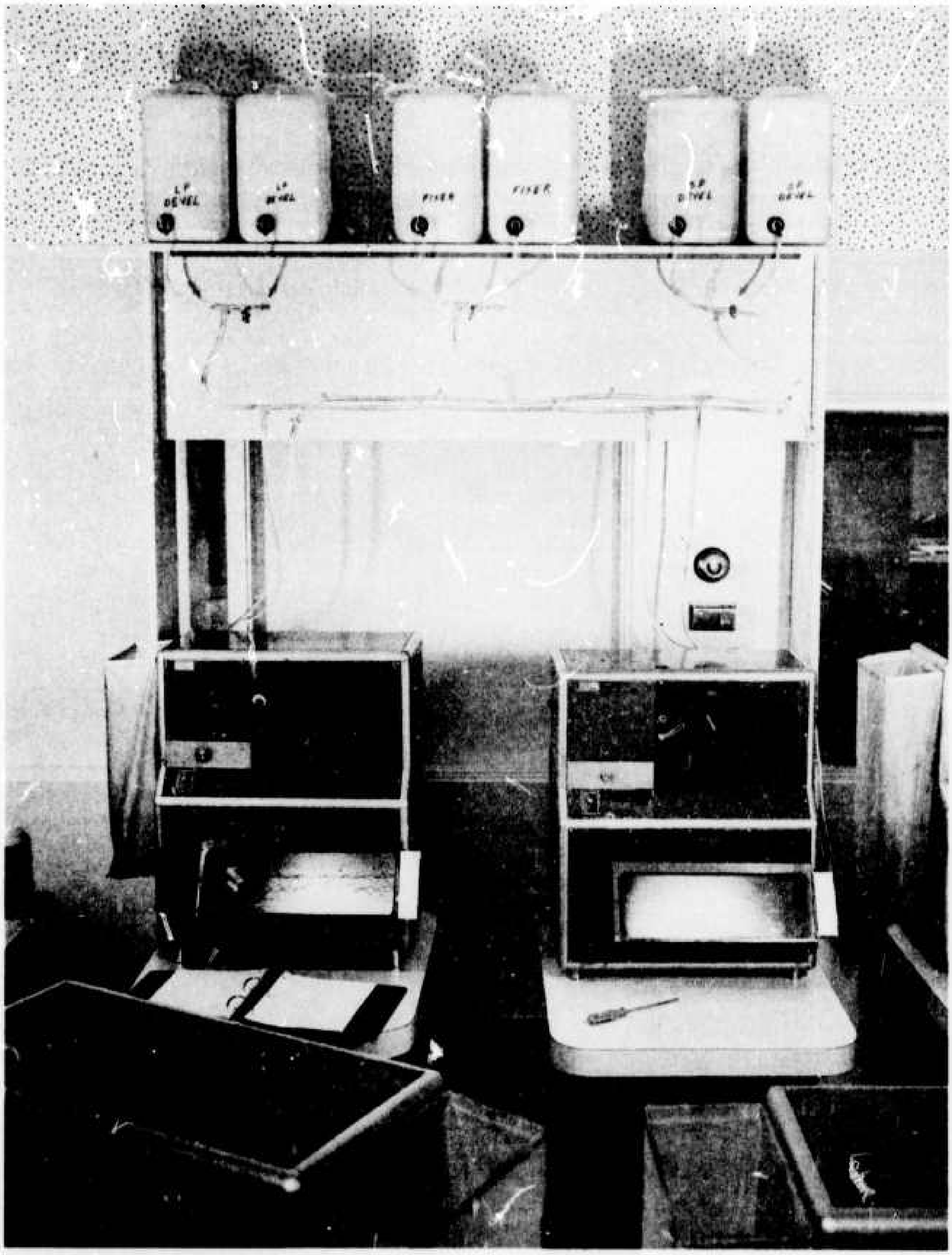

Figure 4. Gravity feed chemical supply system with centralized supply tanks

G 7030

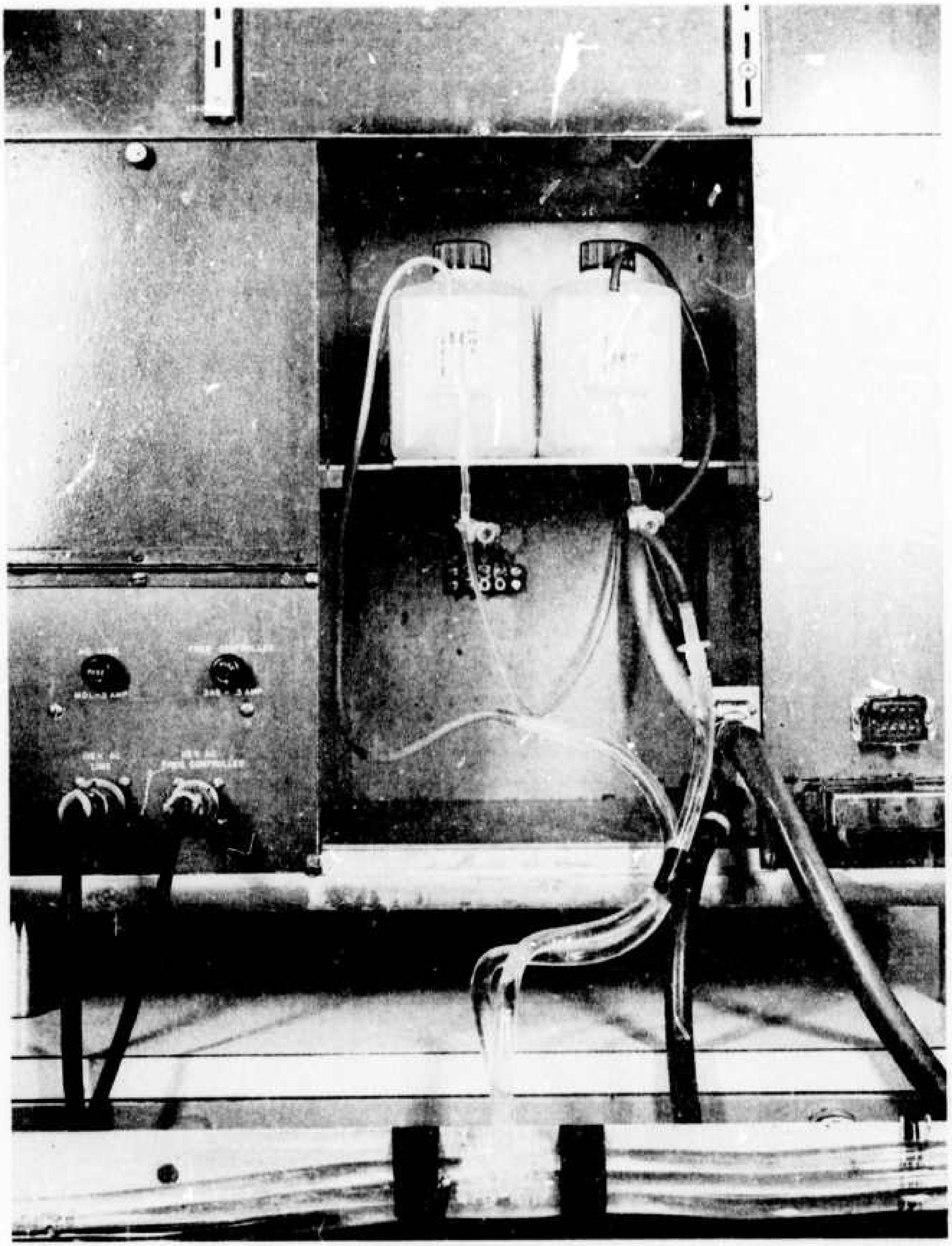

Figure 5. Gravity feed chemical supply system connections to Develocorder

G 7031

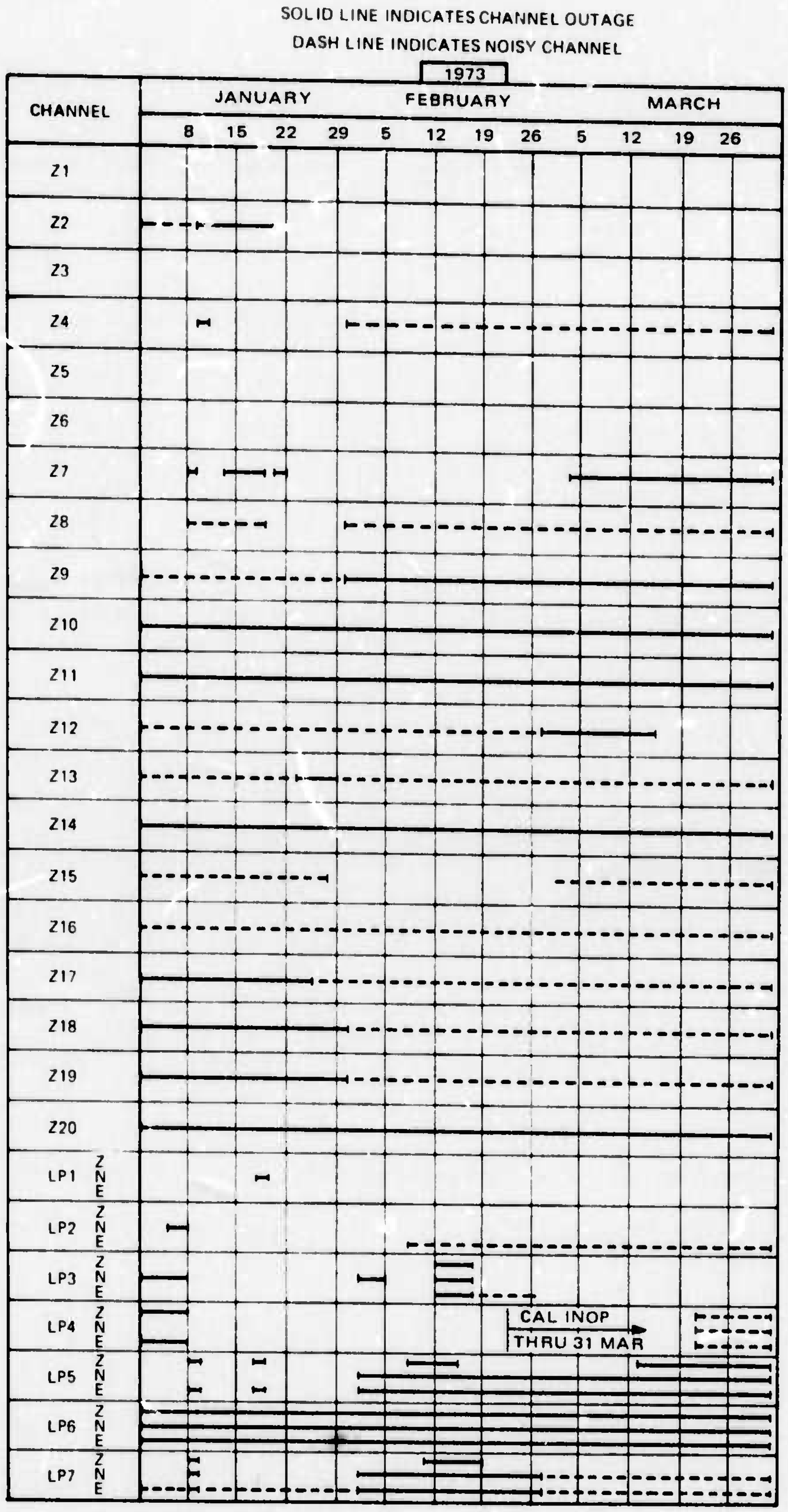

Figure 6. TFSO channel outages

3.7 LAMONT-DOHERTY ENCLOSURE

From 1 January to 25 January, data from the instrument in the Lamont tank continued to be noisier than data from the instrument in the control tank. On 25 January, the earth and the wooden lid over the Lamont tank were removed, and it was found that the Lamont tank was submerged in five feet of water. The water was pumped out and all connectors on the outside of the tank were found to be dry. Because previous tests had indicated the tank to be well sealed, it was not opened for inspection. The wooden lid was replaced and covered with plastic to shed water. Sawdust was placed over the plastic as an insulating material, and operational tests were continued. Since the water was removed, the Lamont tank channel noise level appears to be approximately one-half the control tank channel noise level at periods above 20 seconds.

Operational tests of the Lamont vault were stopped on 13 March and the seismometers were removed so that they could be refurbished prior to their installation at the LP6 site. The interiors of both the Lamont and control vaults were found to be dry despite their submersion in water.

Test data will be analyzed further and will be compared with data taken from the Lamont and other vaults at LP6. A separate letter report will be submitted to describe the entire vault evaluation program.

3.8 PACKAGE BOREHOLE SEISMOMETER

Detailed designs for all components of the Model 36000 borehole seismometer package were completed. Sketches for all components were drawn, parts were procured or fabricated, and assembly and checkout of subassemblies were completed. Figure 7 shows, from top to bottom, the cable strain relief connected by a chain to the stabilizer assembly, which is connected to the top of the main transducer package. The outer case was not on the transducer package in this photograph. Figure 8 shows the holelock which will support the transducer package in the borehole. Figure 9 shows the installation tool that will be used to install the holelock in the borehole. The impact tool is shown removed from the remainder of the assembly. Figure 10 shows the installation tool mated with the holelock.

The testing and evaluation of this instrument is being accomplished under another contract.

Figure 7. Upper subassemblies of the Borehole Seismometer, Model 36000

G 7032

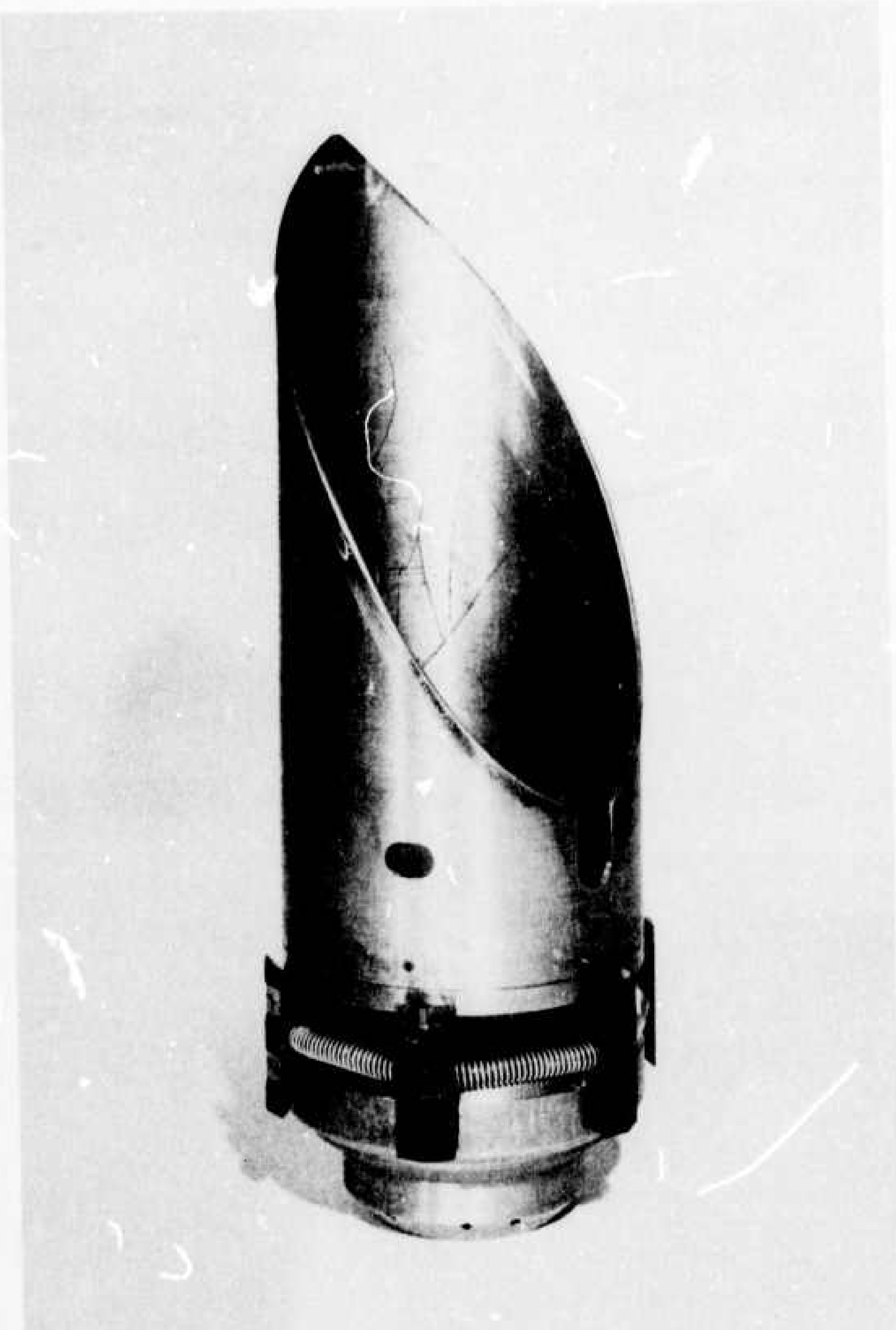

Figure 8. Holelock for Borehole Seismometer, Model 36000

G 7191

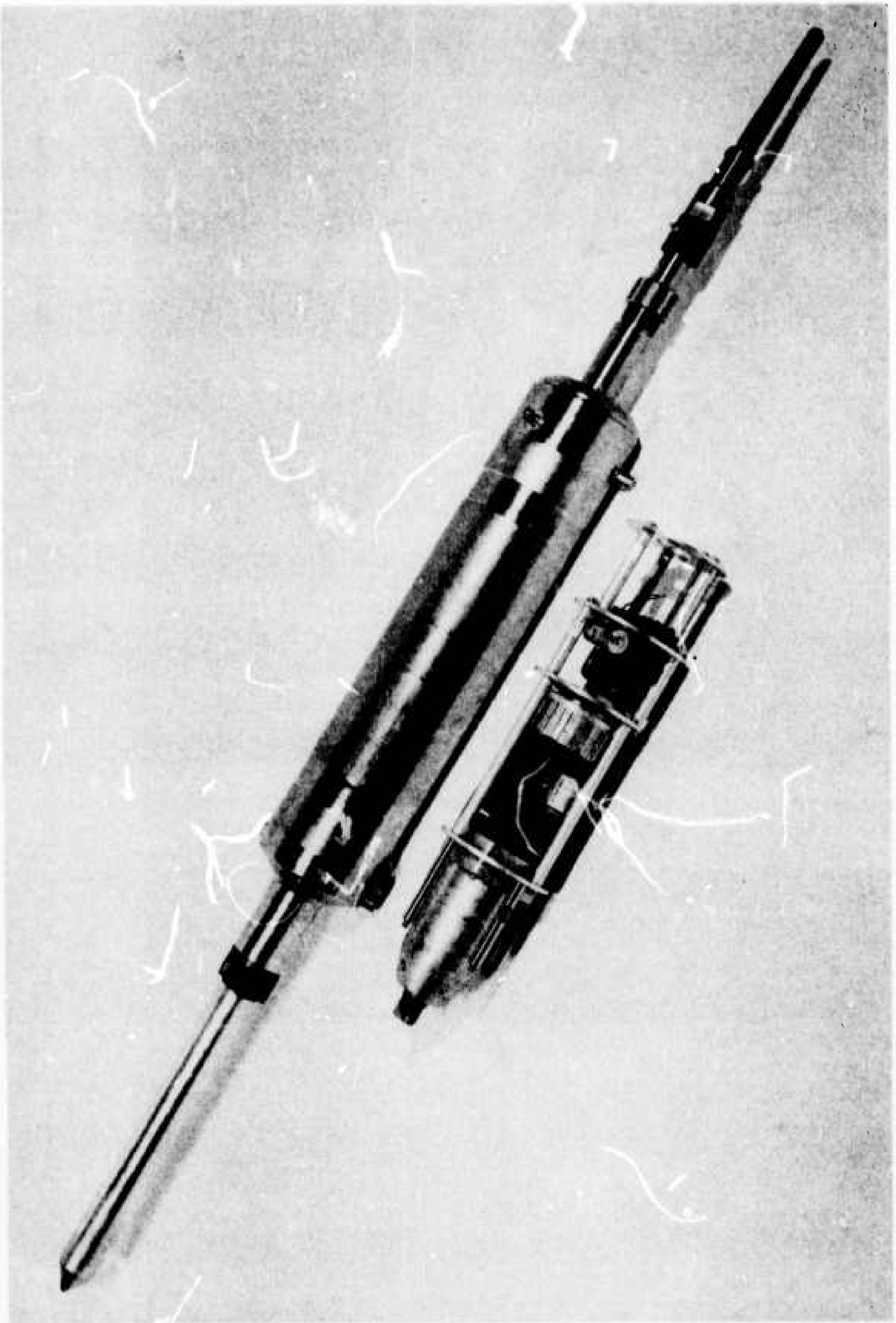

Figure 9. Installation tool for Borehole Seismometer, Model 36000

G 7034

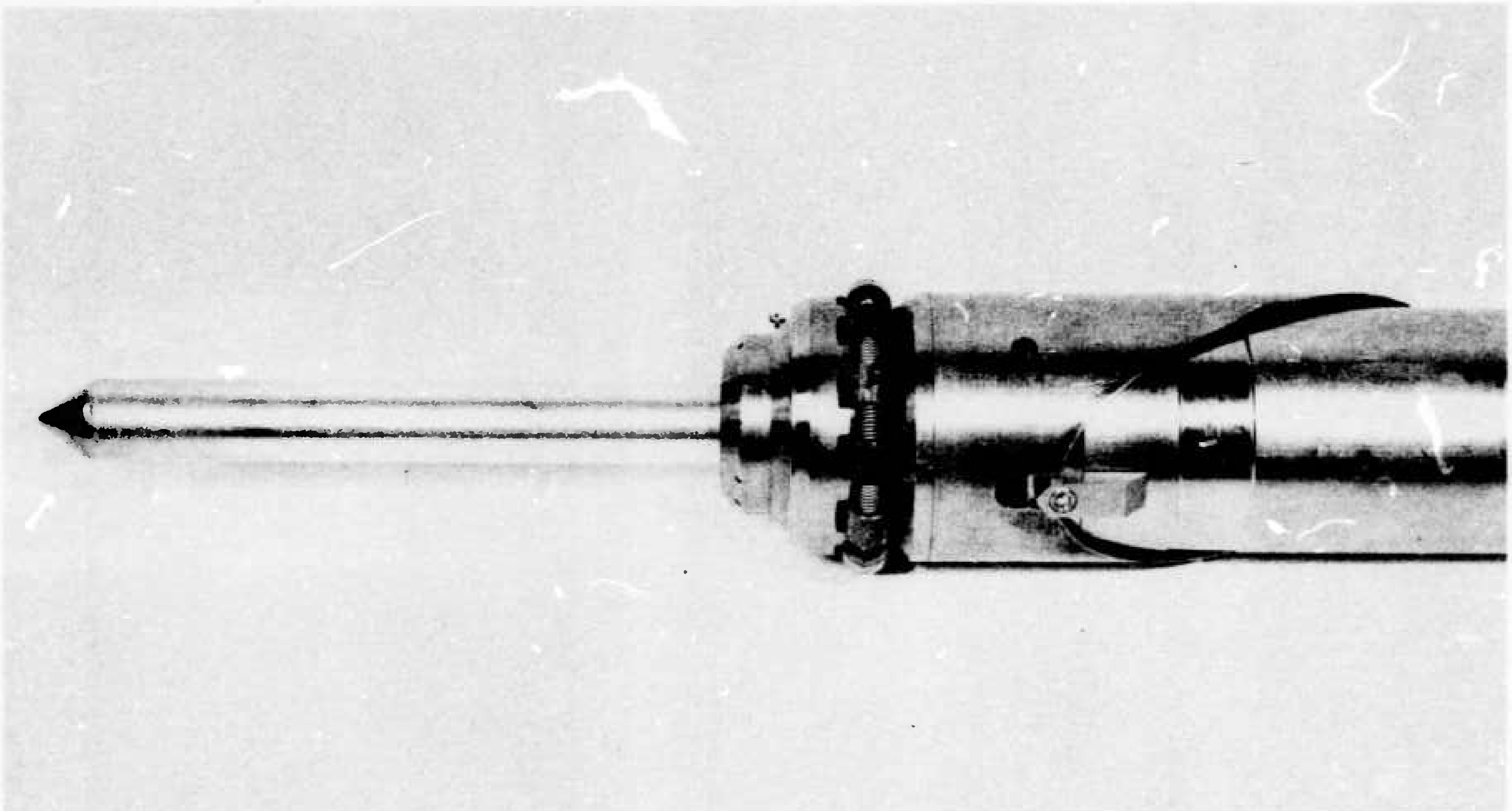

Figure 10. Installation tool mated with holelock. These are used with the Borehole Seismometer, Model 36000

G 7035

3.9 DEVELOCORDER PROJECTION LAMPS

A life test of Develocorder projection lamps was begun in September to determine the relationship among operating time, lamp life, and duty cycle. More specifically, the test was begun to determine if the lamp life could be extended by operating it only during the observatory manned periods (approximately 9 hours per day) rather than by operating it continuously. It was not known which would affect lamp life more: (1) the thermal shock of turning the lamp power on and off each day; or (2) the longer operating time of continuous operation.

The first data indicate that thermal shock has little effect on lamp life, and that it is advantageous to operate the lamps only during 9 hours each day. These data are:

Mode of operation	Lamp life	Lamp operation
Continuous	35 days	840 hours
9 hours per day	126 days	1234 hours

These tests will be continued to collect more representative data.

4. PROVIDE OBSERVATORY FACILITIES AND ASSISTANCE TO OTHER ORGANIZATIONS

4.1 VISITORS

As part of an effort to acquaint staff members of the U.S. Forest Service with the occupants of the Tonto National Forest and their use of the land, Ranger Phil Smith brought Mr. Hal Watson and Mr. C. H. Thiede of Albuquerque, New Mexico, and Mr. John Blackwood of Phoenix, Arizona, to the TFSO on 24 January. They were given a tour, and the functions of the observatory were described.

Captain John H. Fergus, Jr., Project Officer, USAF, and Mr. B. B. Leichliter, Program Manager, Teledyne Geotech, visited the TFSO from 21 through 23 February to review and discuss work progress and plans.

Mr. M. J. Benham, Phoenix Jr. College, and 16 geology students visited the TFSO on 23 March.

APPENDIX 1 to TECHNICAL REPORT NO. 73-5

STATEMENT OF WORK

PART II - THE SCHEDULE
SECTION F - DESCRIPTION/SPECIFICATIONS

STATEMENT OF WORK TO BE DONE
(AFTAC Project Authorization No. VELA T/3704/B/ASD)

1. Objectives: The Tonto Forest Seismological Observatory (TFSO) is unique in its low level of background seismic noise and in its capability as a research center, being equipped with various film, paper, and analog and digital recorders, a shake table, a large walk-in vault for instrument evaluation, and assorted test and measurement equipment. The purpose of this project is to operate this observatory as a source of high-quality seismological data for use in Government-sponsored research projects, to use the TFSO as a field test site for evaluation of new seismological instrumentation and procedures, and to support other research projects as directed by the project officer. This project should require a technical manning level of approximately four man-years.

2. Tasks:

a. Operation.

(1) Continue operating the TFSO according to established procedures (Standard Operating Procedures for TFSO, 1 Nov 1970), providing recorded data to the Government. Special data requirements anticipated will include, but not be limited to, recording signals from special events at the Nevada Test Site and supplying beam-formed, or multichannel filtered data, for use in evaluation of the effectiveness of the ARPA long-period arrays: Montana Large Aperture Seismic Array, Alaskan Long Period Array, and Norwegian Seismic Array.

(2) Quality control the data acquisition systems and evaluate the seismic data recorded to determine optimum operating characteristics and perform research to improve operating parameters to provide the most effective observatory practicable. Major reconfigurations in equipment, those requiring more than 48 hours to remove, are subject to prior approval by the project officer.

(3) Provide use of observatory facilities and seismological data to requesting organizations and individuals as identified by the project officer.

(4) Maintain, repair, protect, and preserve the facilities of TFSO in good physical condition in accordance with sound industrial practice.

b. Instrument Evaluation. Evaluate the performance characteristics of experimental equipment identified by the project officer. This work includes investigation of the operational capability of dry film recorders, evaluation of the use of a single seismometer for obtaining both long- and short-period data, and study of altered modes of operation of cable

links and radio transmission of data. Additional investigations will be initiated as problems requiring investigation are identified. The total level of effort on this task will not exceed one man-year.

c. Upon identification and prior to the disposition of any equipment determined to be excess to the needs of the project, the contractor shall notify the project officer.

APPENDIX 2 to TECHNICAL REPORT NO. 73-5

TEST PLAN
MODIFY DEVELOCORDER GRAVITY FEED SYSTEM

11 January 1973
M. G. Gudzin

TEST PLAN

MODIFY DEVELOCORDER GRAVITY FEED SYSTEM

1. PURPOSE

This test plan describes a new Develocorder gravity feed chemical supply system that will be installed at the TFSO. Its principle features are the use of increased chemical supply pressures, and the use of three dual reservoirs to furnish chemicals to all TFSO Develocorders.

2. SYSTEM DESCRIPTION

Photographic film processing chemicals will be furnished to eleven Develocorders from six 5-gallon supply tanks (carboys) sitting on a platform approximately 8 feet above the floor. Two supply tanks will be used for LP developer, two for SP developer, and two for fixer. Only three tanks will be in service at any time. The other three will be clean and empty, ready to be filled and used when those in service require cleaning or other maintenance. Each tank will be connected to the distribution system through a quick disconnect fixture. Chemicals will be distributed through 1/4" Tygon tubing. Compression clamps will be used to squeeze the Tygon tubing at various points in the system and stop the flow of chemicals as required.

There are two groups of Develocorders at TFSO. The group of three near the supply tanks will be served by one leg of the distribution system. The group of eight in the center of the room will be served by another leg. The two supply lines in the first leg will be short and will connect directly to the Develocorders. The three supply lines in the second leg will be long and will run under the computer floor, through T-connectors near the lowest point in the line, and then to the Develocorders. The underfloor T-connectors will provide easy means for draining any sediments that may collect in that line.

Settling tanks will not be used in the new system. The bottles now used for this purpose will be cleaned, refilled with plain water, capped, and will be used to physically support the system flow meters.

3. INSTALLATION

Build a wooden rack approximately 8 feet tall to support the supply tanks. The top, which will serve as a shelf, should be 66 inches long by 12 inches deep. Use 2 x 2's or 2 x 4's as structural members and 3/4" thick plywood as the shelf material. Fasten a 1 x 10 or a piece of plywood across the front of the rack, approximately 12" below the shelf, to support the hoses and fittings connecting to the supply tanks. After painting the structure to match the CRB walls, secure it to the wall in the location shown in figure 1, and cover the top shelf with a rubber mat that can be easily cleaned.

Cut a hole in the calibrated end of each supply tank near its bottom and install the bulkhead fitting and polyethylene elbow as shown in figure 4. Mark each tank with Marks-A-Lot just above the bulkhead fitting to identify its contents as SP DEVEL, LP DEVEL, or FIXER.

4. OPERATION

Each 5-gallon supply tank will weigh approximately 40 lbs. when filled and probably is too heavy to be lifted into place. It is suggested that each tank be placed on the shelf empty, and that it be filled using a plastic one-gallon pitcher or similar container, and that it be removed only for cleaning.

The supply tank caps should be screwed loosely in place at all times to keep the contents clean. They must not be tight, as air must be able to bleed into the tank to replace the fluid dispensed to the Develocorders.

The following operating schedule is recommended:

1. Initially fill one supply tank with fixer, one with SP developer, and one with LP developer.
2. Operate routinely for several days to determine chemical usage rate.
3. Refill tanks on a regular (weekly, biweekly, or monthly) schedule as determined by usage rate. Refill before the fluid level falls below one gallon.
4. Every two months, drain about one pint of fluid from underfloor lines.
5. Every six months, drain and flush all lines with clean water, change supply tanks, and clean tanks that had been in service.

5. REPORTS AND DATA

Take photographs of all parts of the installation. Report work progress and system performance in the monthly station reports.

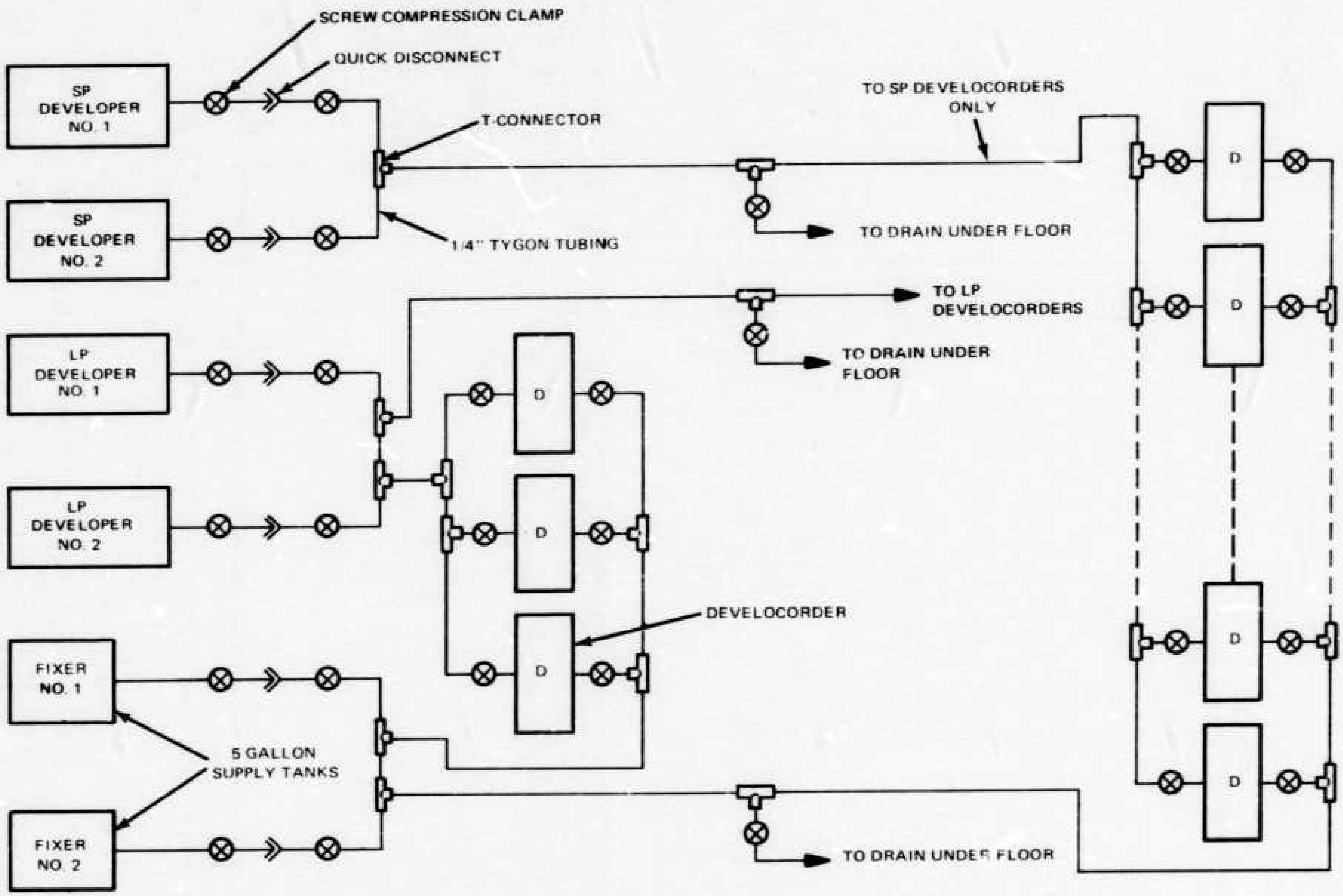

Figure 1. Schematic of modified Develocorder gravity feed chemical supply system

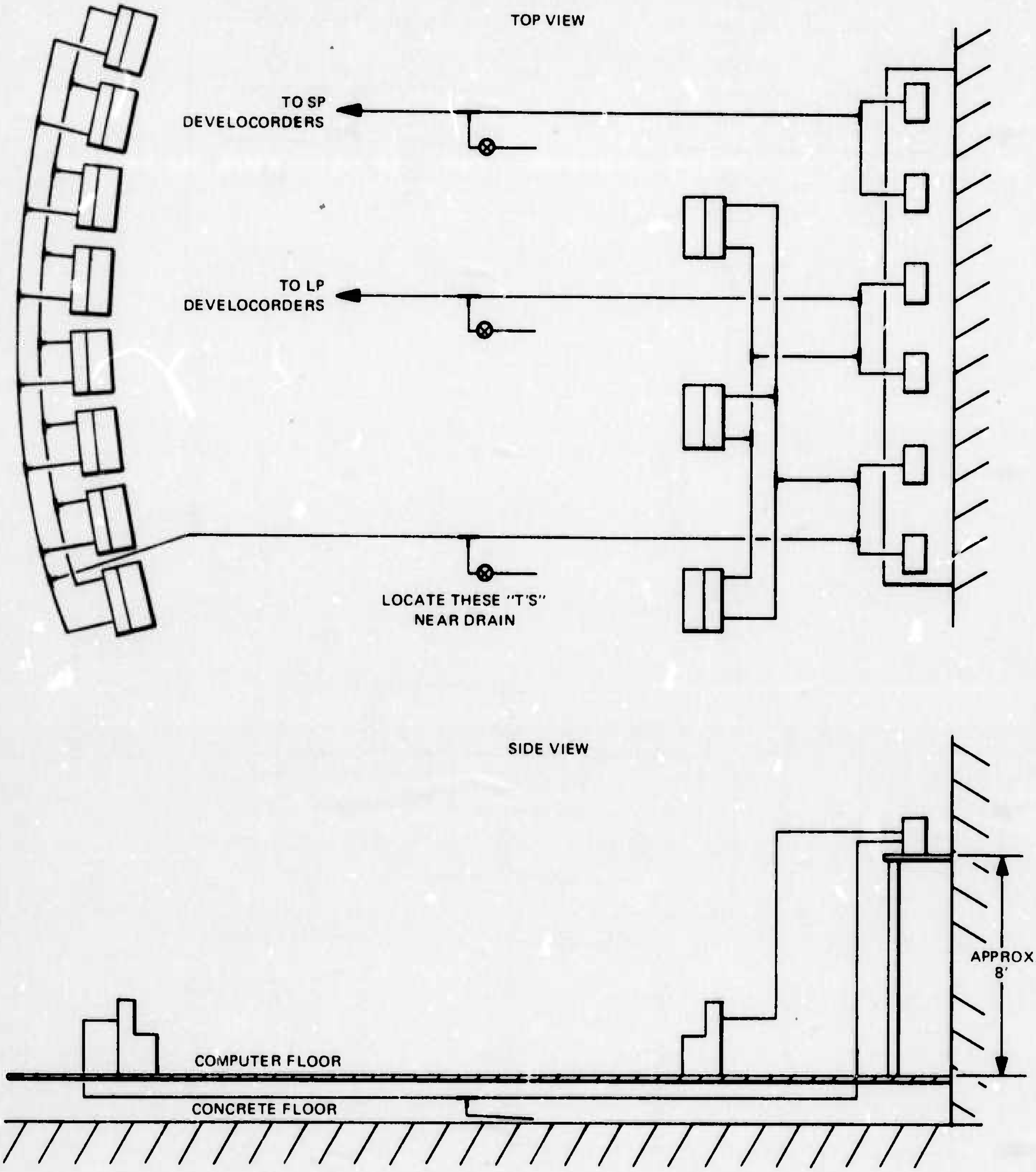

Figure 2. Sketch showing general arrangement of gravity feed system components

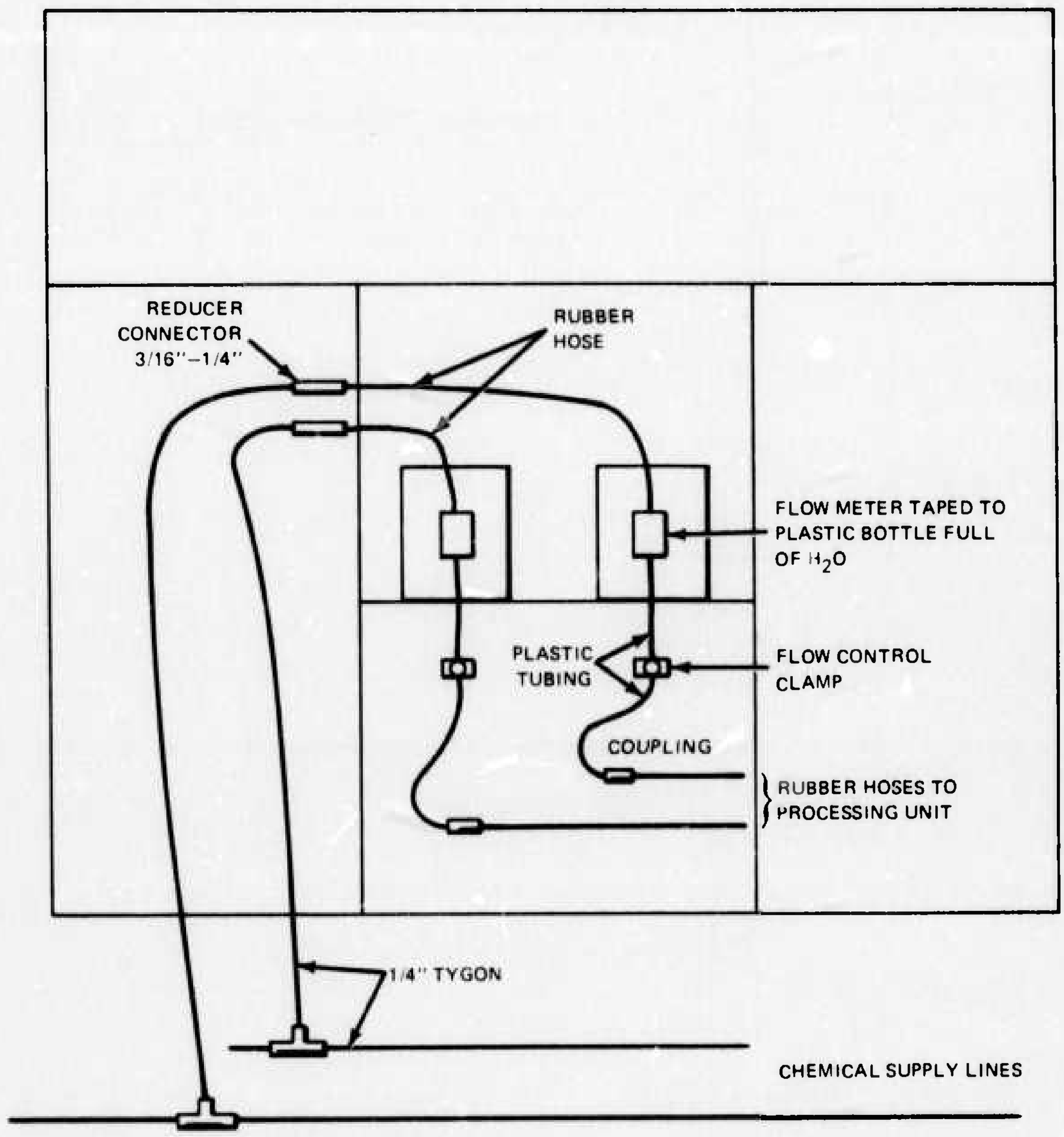

Figure 3. Detail of supply line connections to Develocorder

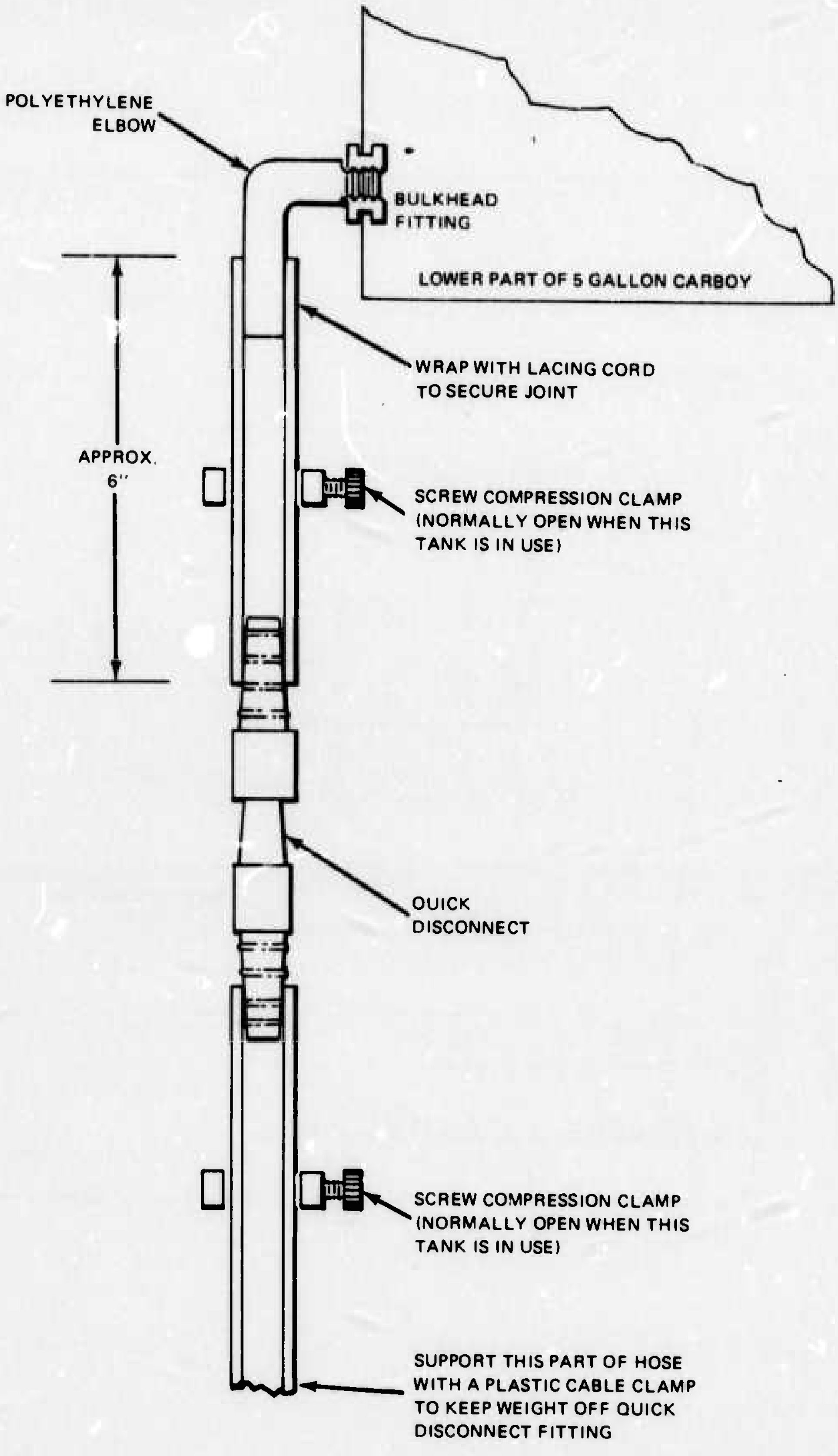

Figure 4. Detail of connections to supply tank